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Computer Technology and Woven Textile Design / or CAD

### Original Citation

Sinha, Pammi (2012) Computer Technology and Woven Textile Design / or CAD. In: Woven Textiles: Principles, Developments and Applications. Woodhead Publishing Series in Textiles . Woodhead Publication, Cambridge, UK, pp. 205-228. ISBN 9781845699307

**Chapter 6: Computer technology and woven textile design / or CAD**

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Chapter contents (including section headings),



**Diagrams and tables**

## Abstract and key words

This chapter introduces some key issues regarding the use and role of CAD within the global textiles trading environment, such as: cost, expertise and skills training, impact on the supply chain and development of new products and new market areas. The chapter concludes by discussing some of the current research being undertaken with CAD applications for woven textiles with a view towards future trends and sources of useful information for readers wishing to explore the issues raised in greater depth.

*Key words: CAD, consumer woven fabrics, technical textiles, supply chain impact*

## Chapter 6: Computer technology and woven textile design / or CAD

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### 6.1 Introduction

Weaving is one of the oldest crafts known to man. Fragments of woven cloth have been dated to the Neolithic/Eneolothic period (Soffer 2004). The woven fabric has been regarded as possessing mystical qualities: woven rags are offered as part of the prayers in some Buddhist shrines, form the requisite set of ceremonial accoutrements for many different religions' prayer settings and, as observed by Kramrisch (1968) "in the Rig Veda and the Upanishads, the universe is envisioned as a fabric woven by the gods. The cosmos, the ordered universe, is one continuous fabric; the uncut fabric is a symbol of totality and integrity" (Kramrisch, 1968, pp, 67-68). Knowledge and mastery of the skill has long been a matter of intellectual pride – as illustrated by the Greek myth of goddess Athena's punishment meted out to Arachnida of being turned into a spider to forever spin and weave as a result of her demonstration of pride in winning a weaving competition between them. To understand and be knowledgeable about woven design is still a matter of mastery of weaving technique and mathematics and the competitive environment within which the textiles industry operates requires computer aided design (CAD) skills to develop new products and new textiles applications.

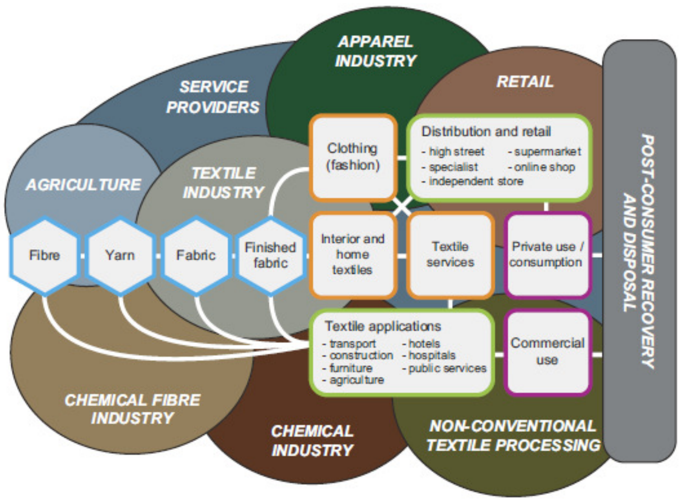
This chapter introduces the reader to some of the key issues regarding the use of CAD within woven textile design. Section 6.2 begins with an overview of the scope and standing of the textiles industry within the global trading environment and the role that CAD has to play. Sections 6.3 to 6.7 then discuss key issues when using CAD within the woven design process such as: cost, expertise and skills training, impact on the supply chain and development of new products and new market areas. Textiles, as has been noted already, have consumer markets (such as clothes and interiors) as well as technical (industrial) applications. Section 6.8 concludes this chapter by discussing some of the current research being undertaken and briefly considers some of the aspects of CAD expertise required within the expanding area of technical textile area and presents sources of useful information for readers wishing to explore the issues raised in greater depth.

## 6.2 CAD and the Global Textiles Industry

According to the Organisation for Economic Co-operation and Development (OECD), the biggest exporters of textile and clothing products are China (followed by Hong Kong China, Italy, Germany, United States and India). The latest figures regarding world trade in textiles and clothing was about US$610 billion, i.e. about 4.3% of the world's exports (Kowalski and Molnar, 2009).

The Textiles sector is wide and diverse with applications as diverse as clothing, geology, architecture, auto industries, civil engineering, medicine, aerospace, etc, (figure 1, after Euratex, 2004). The textiles industry has traditionally been regarded as consisting of several discrete but related areas of production: fibres (natural or synthetic), yarns, fabrics, wet processes (such as dyeing or finishing) and the finished product (consumer goods eg clothing, domestic interiors).

**Figure 1: the textiles and clothing industry sector (Allwood et al 2008)**




Production of fabric is capital intensive, requiring technology and automation to produce requisite volumes of fabric. Although more labour intensive, the consumer end of the chain (import, distribution and retail) has become increasingly competitive and significant in the industry's value chain (OECD, 2006; Nordas, 2005) and new applications of textiles have led to expanding market potentials for technical textiles. New technology, research and development activities are regarded as essential factors to compete within the capital intensive countries (such as those within the OECD) as it helps to develop products that are differentiated from competing companies and are able to be traded within the saturated market conditions, CAD is an important factor in developing differentiated products and reacting to the changing nature of the supply chain.

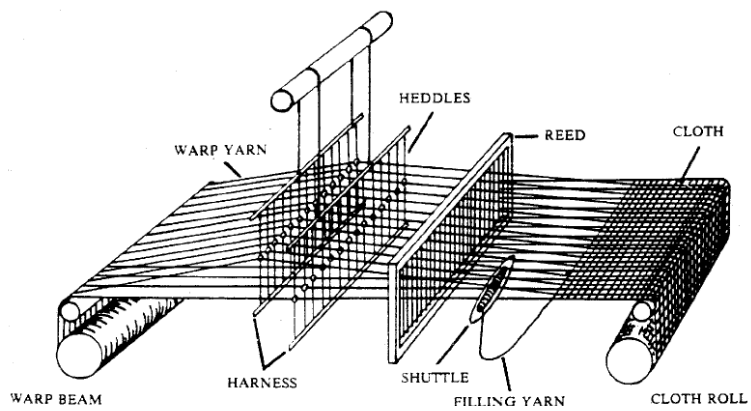
### 6.3 Key issues in the use of CAD for the woven textile design industry

Before consideration of the issues raised by using CAD, a very brief reminder of the key operations regarding woven textile design is presented to illustrate how CAD initially became a vital part of the textiles industry. The first section demonstrates how basic weave knowledge of techniques and manufacture are required to work with CAD software for consumer textiles. The following section will appraise how knowledge of weave skills, techniques and manufacturing technologies have been coupled with CAD to further research and development of woven fabrics.

6.3.1 *Basic weave design features:*

Weaving has been described as “the art of interlacing one element in and out of one another” (Gillow and Sentence, 2004, p68) and woven structures are formed by interlacing one set of yarns with another set oriented in the opposite direction. Yarns that form the length of the fabric are called the *warp*; the yarns that cross or interlace the warp to form the pattern are called the *weft* or filling yarns (Corbman, 1975).

**Figure 2: Components of a Typical Shuttle Loom (Wingate 1979)**




A weaving loom has the following components to enable fabric formation (see Figure 2, Wingate 1979):

- Warp beam: the warp yarns are wound onto this beam
- Heddle  a wire with an ‘eye’ in the middle of it to feed a warp yarn through
- Harness: a frame to which a group of heddles are vertically attached in a series. The weave operation is achieved through the raising and lowering of the harness. A separate harness is used for each group of warp yarns arranged to be moved as a group to weave a desired pattern.
- Shuttle: carry the weft threads back and forth across the loom (this may be replaced by a variety of other methods, eg air, water etc)
- Reed: maintains the warp spacing at the required spacing and presses or battens each filling yarn (weft) to form the fabric.
- Cloth beam: to collect the newly constructed fabric.

Loom operation requires the following processes: warp let-off, shedding, filling insertion, beat-up and fabric take-up (Arora, 2008):

*Warp Let-Off:* the mechanical or electronic mechanism that controls the rate of flow of warp yarn to be let off the beam with consistent and appropriate tension setting to achieve efficiency of the weaving process.

*Shedding:* the action of some warp yarns raised and some yarns lowered to form a ‘shed’ through which the filling yarn passes. The warp yarns are grouped and passed through a harness. The grouping of warp yarns, the number of harnesses and the sequence in which the warp yarns are raised and lowered is are determined by the design (weave structure).

*Filling Insertion:* the term for the filling yarn being inserted through the shed. The filling yarn is inserted by a carrier device such as shuttle or shuttle-less technologies such as projectile, air jet or water jet. As the filling yarn is inserted, the carrier device moves across from one side to the other of the shed, the edges of the fabric, selvage, are formed. A single movement across the shed is called a ‘pick’.

*Beating up:* an inserted filling yarn is not able to be placed directly into the correct position at the shed opening as it physically cannot fit into the acute angle of the shed opening. The filling yarn is pushed into its final position (the cloth fell) by a reed and this action is referred to as beating up. The cloth fell is an imaginary line where the cloth starts to be formed. Beating up takes place after the shuttle has moved through the shed. Beating-up gives the fabric firm and compact construction. The speed with which a loom operates is quoted as 'picks per minute' and signifies how many times the weft yarn moves across the warps yarns and is beaten up within one minute.

*Take up:* as the fabric is formed, it needs to be removed from the weave area and is wound onto a cloth beam. The rate at which this takes place is one of the elements that control the filling density (picks per centimetre or picks per inch), the other is the weaving machine speed (picks per minute).

All types of looms, in industry, may be computer controlled both at the design end (CAD) and at the manufacture end (CAM). The interaction of CAD/CAM has helped to reduce the number of fabric faults and increased the production rate of fabrics. Weave patterns (structures) depend on the number of harnesses and the sequence of shedding and the shedding motion is of vital importance to understand. There are three different types of attachments for shedding motions: tappet, dobby and jacquard.
Tappet shedding is the simplest and least versatile shedding motion; it is a mechanical movement using tappets and cams to control the up/down movement of the harnesses. The is bulky and limits the loom to control up to 8 harnesses and the design is restricted to plain weave, simple twill and simple sateen or satin weave. Any design requiring more than 8 harnesses requires a dobby loom.
Dobby shedding is a compact, electronically guided shedding motion and capable of having up to 28 harnesses; it therefore is capable of more complex and versatile shedding motion with much greater weave repeat. Design may be woven with two or more basic weaves and their variation and fabrics woven using dobby shedding are often referred to as dobby cloths or dobby weave.
Jacquard shedding provides unlimited design width as there are no harnesses, instead the individual warp yarns are independently controlled through cords attached to a Jacquard head. Modern jacquard looms are electronic and designs are input through CAD with the potential for figured, non-repeat or large and complex patterns.

### *6.3.2 Woven technical textiles*

According to the Technitex group (www.technitex.org) the term 'technical textiles' was coined in the 1980's to follow on from the term 'industrial' textiles (which is still used in the USA), as it was regarded as too narrow in scope of applications. ‘Technical textiles’ were initially regarded as ‘textile materials and products manufactured primarily for their technical and performance properties rather than their aesthetic or decorative characteristics’ but technical textiles are being used within sportswear apparel and the increasing use of design to attract consumer sales has rendered a purely functional approach somewhat narrow (Byrne, in Horrocks and Anand, 2000). Knitted or woven fabric structures may be used for technical textiles range (Sherburn, 2007). Chris Byrne (2000) provides some common features of technical textile products: they are the results of understanding and know how about combinations of the techniques of manipulating fibres, fabrics and finishing and how they perform in different combinations and environments.

Woven fabrics may be single layer or multiple layers and the weave structure may be plain through to complex, depending on the final product requirements. Multilayer woven fabrics are also known as 3D weaves, as they have several layers of warp and weft yarns woven together in an almost infinite number of possible ways, but broadly categorised as orthogonal, through-thickness angle interlock and angle interlock (also known as layer-to-layer). Braided fabrics (created by interweaving two or more yarns in a diagonally overlapping pattern) are also commonly used to develop technical textiles. Two types of braided fabrics are widely available, biaxial (two sets of aligned yarns) and triaxial (three sets of aligned yarns). As with woven fabrics, multilayered (3D) braided fabrics are also manufactured. 3D weaving may result from specific loom technologies such as 3Tex and Biteam or through a conventional weaving loom (Chen 2010). Use of a conventional loom has the advantage of readily available technology, flexibility in the types of 3D structures to be produced and lowered costs. The disadvantage of using a conventional loom is that it can be complicated to design and manufacture 3D fabrics in this way (Chen, 2010).

Technical textiles are interdisciplinary in nature; “cross-discipline collaboration between textiles and engineering” were noted to be increasingly commonplace within research and industry by woven textile designer and academic Julie Soden (2001). She also noted that although these types of projects resulted in mutually beneficial outcomes, there were challenges regarding communication such as terminology and a basic understanding of specific technical requirements and limitations. To design technical textiles, the designer needs to have a very good understanding of the yarn and its properties, particularly because much of the 3D woven fabrics are used for applications such as textiles reinforced composite materials (TRCM) – where both the materials used as the matrix and the reinforcing material (such as textiles) retain their individual properties at microscopic level. Textile composites may be textile structures within polymers, ceramics or metals (Ogin, 2000). Building upon this knowledge, the ability to conduct mechanical or geometrical modelling of the textiles is paramount. According to Sherburn (2007), geometric modelling of yarn as "solid volumes representing the approximate bounds of the fibres contained within them" (Sherburne, 2007, p5) for application in composite textiles is important because it enables:

- Determination of the mechanical properties of the fabric forming behaviour.
- Prediction of the permeability of fabrics for processing of composites.
- Modelling of the mechanical properties of composite parts and their adverse behaviour for use in engineering applications.

### 6.4 Necessary Expertise and Skills Training for Woven CAD Textile Designers

Weave designers need to be multi-skilled and understand both the supply and cost issues, the specifications for production such as fabric analysis, drafting the pattern, tensions as well as computer aided design packages. Skillfast UK (2008) conducted a survey of fashion and textiles industry to identify the skills considered to be necessary for a variety of roles. Table 1 illustrates the skills regarded as necessary for a weave designer. Most textile companies require new employees to have a working knowledge of CAD, even where they provide some in-house training from the software providers. Most new textile designers will learn their skills at universities or colleges of textiles. To become adept in the use of CAD, one must understand the principles of weaving. The basic principles tend to be learnt initially through hand weaving classes; at university or college, this often requires a year to master before the student undertakes designing through CAD. Proficiency in CAD for technical textiles requires not only fundamental understanding of fibre properties and CAD but also mathematical modelling techniques and skills that can be applied to leverage the fibre and fabric properties. To acquire the specialist knowledge and expertise of a technical textiles CAD weaver requires study and training at Masters Level or beyond, ie this is a highly specialised area that tends to be located in the R&D areas of companies or universities. There are a number of weave CAD software packages available to both education and industry. As noted earlier in this section, a credible weave designer needs to display a working knowledge, if not some degree of expertise, in using CAD. There are, however, two general, main issues with regard to using CAD in weaving: cost and weave application (ie commercial/domestic or industrial/technical use).

**Table 1: National Database of Accredited Qualifications: Woven Fabric Design (reference no. R/502/2281)**

| learning outcome | | assessment criteria | |
|---|---|---|---|
| 1 | Understand the process of woven fabric design and development from initial idea to finished product | 1.1 | Analyse the factors impacting on design development |
| | | 1.2 | Describe the different types of repeat and their application |
| | | 1.3 | Explain the processes of design from initial idea to finished product to include:<br>• Research<br>• Interpretation of design brief<br>• Customer requirements<br>• Costings<br>• Design specification,<br>• Sample requirements<br>• Sample production<br>• Production Specification |
| 2 | Understand the principles of technical drafting | 2.1 | Explain the principles of technical drafting for each of the following: Plain fabric, twill, stain and sateen weaves |
| | | 2.2 | Draw a technical draft for two designs to be woven on two different types of machine |
| 3 | Be able to use CAD techniques in woven fabric design processes | 3.1 | Describe CAD – Computer Aided Design techniques and processes |
| | | 3.2 | Produce a design for a woven fabric using CAD – Computer Aided Design |
| 4 | Understand fabric analysis techniques | 4.1 | Describe sample analysis techniques for: Fibre type, Yarn type and count and Type of fabric |
| | | 4.2 | Analyse two woven fabrics of different construction and for each of the following: produce fabric notations, measure fabric parameters and carry out calculations |
| 5 | Understand the principles and processes of weaving | 5.1 | Describe the primary motions of weaving |
| | | 5.2 | Explain the manufacturing processes and production cycle of woven fabrics |
| | | 5.3 | Explain factors influencing handling characteristics of materials during processing |

## 6.5 Costs incurred in using CAD

A term most often associated with CAD is ‘investment’ and it is often the larger companies who are suppliers or part of a global network that spend the most and benefit from this. The costs of software are varied and cannot be estimated in a simple manner. The costs of buying CAD package may vary from £1000's to multiples of £10,000's; factors that influence the actual and final cost include the following:

- The license to use the software (and numbers of –each person requiring the use would need to have the license)
- Whether 'floating' licenses and 'keys' are required (to use in –situ at the company offices or studio or on lap top away from the office)
- Training to use the software, which includes:
    - A trainer's daily fee
    - The costs of travel for the trainer to come to the studio
    - Any further expenses incurred by the trainer for overnight stay and sustenance
- Computer platforms to support the use of the software (and what are they compatible with)
- Peripheries (eg printers, links to CAD/CAM at other sites, links to factories, etc).
- Servers to store or access the information
- Any annual subscription or payment for annual software update

## 6.6 CAD Software applications

As noted earlier, the scope of the textile industry is vast and spans domestic and commercial applications to industrial and technical textiles (such as geo-engineering, medicine and heavy industry). The types of software systems and packages vary between the two types of industries, in both the systems and use of the software.

### *6.6.1 Domestic/commercial applications*

Windows ® is the most common operating platform for the software but Apple Mac ® and Linux are also used. The designs are generally able to be read across the different platforms to avoid, as far as possible, technology 'lock in' by the textile manufacturers. In general, weave software is built up as separate packages of a variety of functions (eg, dobby, jacquard, presentation – to present mood boards and specifications of the designs to potential customers and clients, drape function – to visualise fabric designs on shaped eg sofas and bedcovers, etc). All software packages should be able to print out loom cards or be linked to peripheries such as printers and looms such as sending the instructions directly to looms for manufacture (ie links to CAM - computer assisted manufacturing - processes, most often Bonas or Staubli for jacquard weaving). Four commonly used weave CAD packages (AVA, Scotweave, Textronic and Arahne) have been compared for the purpose of this chapter and they have the following similarities:

- Yarn consumption and cost implications are calculated as part of the design function.
- All have the following functionalities, either as a separate module or as part of the package:
  - draping functions (to visualise the woven fabric design applied to a product),
  - data storage, retrieval, sharing and management systems and presentation methods,
  - presentation – such as texture mapping, story-boarding.

Table 2 illustrates the differentiating features between the software packages, but may be briefly summarised as:

**Scotweave** software has a package for face to face velvet and technical textiles (eg for the automotive industries, geo-textiles, medical textiles, anti-ballistics etc) and has a cross-sectional and 3D visualisation feature which enables the weave structure to be viewed from any desired angle and to identify any defects in the weave structure.

**AVA** is highly popular within the printed textiles industry and so has many specific functions regarding colour matching of yarns to ensure that colour specifications for the designs are maintained throughout the production process.

**Arahne** presents its software as the most cost effective package to be used by industry and educational institutes; it offers the dobby and jacquard software together in one package.

**Textronic** software has a carpet weaving software package which is also capable of being linked to CAM operating looms such as Staubli.

### *6.6.2 Heavy industrial/technical textiles*

The discussion so far has demonstrated the impact that CAD has had on the textile industry in areas that we are commonly familiar with (clothing, automotives, interiors etc). The use of CAD has also developed and propelled the technical textiles sector of the industry into prominence. CAD has been developed for the technical textiles sector on a commercial basis by software development companies but as the research is continuing and developing, academic institutes are also developing software

## Table 2: comparison of some consumer application CAD software

| software package | platform/compatability | special features | weave types | | | | drape | peripherals | systems management | sharing | presentation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | dobby | jacquard | velvet | technical | | | | | |
| AVA Weave (UK based company) | platform - Apple Macintosh Computer, supports Mac OS X; compatible with PowerPC and Intel Mac Computers | | yes - plain weave to mixed construction blankets; cartridge can be linked to AVL loom | yes - requires AVA Quick Separations; design exported to be read by either a Bonas or a Staubli jacquard loom | | | grid and calibrated colour | print out to EPROM Cartridge Loader | AVA QA Pro: central control (lead retailer controls if quality is appropriate) | information about colour and design shared trough the AVA server called Synchronise | AVA Materialize and AVA Colour |
| Scotweave (UK based company) | Microsoft Windows®, can export as TIFF, BMP, JPEG etc. for any Windows®-compatible colour printer, scanner or other hardware | Yarn Designer - create /scan in fancy yarns. Weave 3D to move around weave structure in realtime. Drape 3D - drape with real-time movement. Auto Drape to visualise design in a real setting. | yes. Production data printed (loomcard) or sent directly to electronic dobby looms or direct loom control. | ScotWeave Jacquard Designer with an electronic jacquard loom for design concept to woven fabric. | face to face woven velvet dobby - seperate software to Jacquard Velvet Designer for velvet jacquard fabrics from artwork to loom disk. Includes full weave editing (hole finding) features.also Terry towelling. | Technical Weaver - technical textiles for industrial, commercial and geo-textiles - dobby or jacquard. Includes yarn design, cross section view/edit as well as 3D weave | 3D visualization tool to see ScotWeave fabrics realistically draped over images of garments and other real-life objects. | any microsoft windows printer etc. | electronic dobby or jacquard loom controllers or looms. | | Presentation Program storyboard layout - separate programme from others. |
| Textronic (Indian based company) | Windows based | yarn design facility; also carpet design module integrates to various carpet production techniques - supports Van de Wiele - EP files, Staubli and Bonas. Also for hand knotted carpet weaving. | Production data printed (loomcard) or sent directly to electronic dobby looms or direct loom control. | yes - also design exported to be read by either a Bonas, Staubli, Grosse etc jacquard loom | | | yes | | archiving, data management system - storage and retrieval of design work, security, reports of design and productivity | yes | storyboarding program |
| Arahne (Ljubljana, Slovenia) - CAD/CAM established 1992, from tight cooperation between local textile industry & universities.- Used: China, Croatia, Czech Republic, Denmark, Germany, Egypt, Finland, France, India, Iran, Italy, Morocco, Macedonia, Mali, R | Linux platform, free Apache server. Email as GIF and JPEG or XML for larger production plants. Compatible with Windows, or Mac. Firewalled for security. | both dobby and jacquard are on one programme - ArahWeave. Yarn consumption calculation is in HTML. | yes | yes | | | yes | internet based communication | retrieval system through Perl. | yes - internet but through firewall | |

applications from within textiles related or materials departments. The following discussion is merely an overview of the main features; it is difficult to provide an in-depth analysis of each of the types of software applications available because each application has been developed in response to a particular product requirement and is outside the scope of this chapter .

Various commercial software packages have been produced for designers within textiles composites industries. For example, as described in the previous section, ScotCad Textiles Ltd has been providing CAD software for weaving since 1982. Used by academia to replicate industry environments for students, the ScotWeave package is used to help develop textile designs largely for the commercial arena. According to Sherburn, 2007, many of the functions in the Scotweave package (yarn costing data, scanning feature, image edit tools, library of over 700 weaves, float checking, auto-drape, fabric finishing, import/export weave data, output instructions directly to the looms, etc.) are of limited value to the technical textile researcher. Scotweave's Technical Weaver module, however, models technical textiles at the mesoscopic scale providing some of the functionalities required by the technical textiles designer. Textiles may be examined at macroscopic, microscopic or mesoscopic levels: the microscopic scale examines the yarn, the macroscopic scale examines the woven structure, and an intermediate (mesoscopic) scale examines a few intertwined yarns, which "define the unit cell reproducing the whole structure by a periodic translation" (Boubaker, et al, 2010). A unit cell has been defined as "… the smallest unit of textile that, when tiled, will recreate the full scale textile" (Sherburn, 2007, p. 5). The unit cell needs to be geometrically modelled in order to determine how the yarns are arranged, what the strains on them are and therefore develop predictions regarding their behaviour (shape forming, porosity, breaking, impact damage etc). In the ScotWeave 'Technical Weaver' package, yarn cross-sectional shape and weave pattern can be specified to create a 3D geometrical model. However, according to Sherburn (2007), the ScotWeave 'Technical Weaver' software did not enable calculation of mechanical properties and was limited to modelling orthogonal woven fabrics.

The necessity to be able to mechanically or geometrically calculate and model yarns has led companies and universities to develop software systems of their own. For example CAD modelling systems to provide predictive functions for fabric permeability and composite mechanical properties have been developed: TexGen, WiseTex and TexEng Software Ltd. TexGen (Sherburn, 2007, Robitaille, 2004,

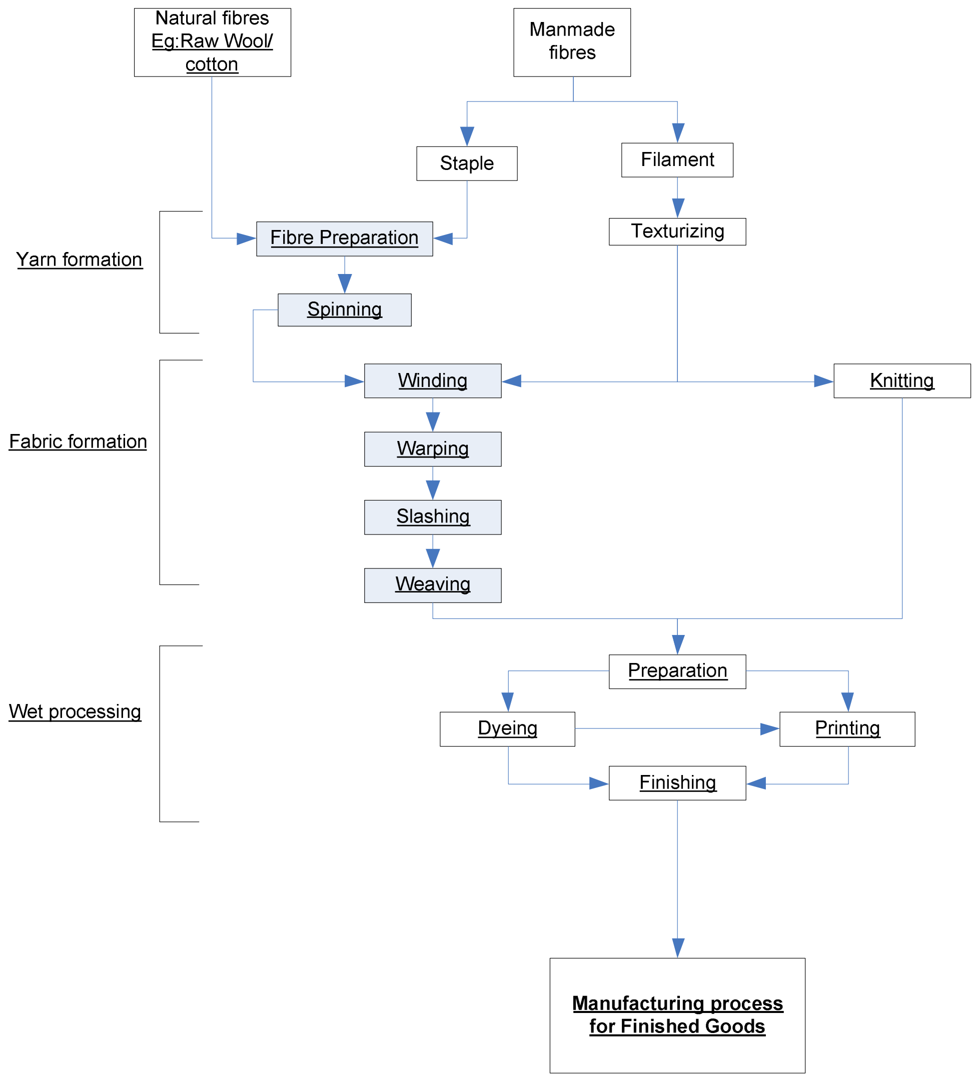
1998) and WiseTex (Lomov and Verpoest, 2000). TexGen, afree and open source licence software (General Public Licensing), operates on Windows and Linux. TexEng Software Ltd is a spin out company developed from research on technical textiles at the University of Manchester (www.texeng.co.uk). TexEng Software Ltd developed Weave Engineer® to support speedy and accurate design and manufacture of 3D solid fabric of multi as well as single layer and Hollow CAD®, to support design of 3D hollow woven architectures with uneven or flat surfaces when opened up, and can be used in the investigation of lightweight textile composites (Chen 2010).

### 6.7 Use of CAD and the impact on the supply chain

Fabric production has three broad phases: yarn formation, winding and fabric formation (knitting or weaving) followed by a wet processing such as dyeing or printing. Computer aided design (CAD) may design yarn compositions or combination of yarns, as well as develop weave structures for woven designs. Printed designs may be undertaken by CAD systems as well but this is usually undertaken once the fabric is woven. The final stages of finishing and volume production of textiles may be completed through computer aided manufacture (CAM). Although the techniques of knitting and weaving share a common heritage of looping/interlacing of yarns to create fabric, they have remained distinct and there is little overlap in the technology used. Within the textile industry there are numerous types of companies that produce or service textile related processing fabric manufacture (fibre, yarn, fabric) for fashion, interiors or industrial goods. Fig 3 illustrates the process of textiles manufacture by weaving and knitting (EPA, 1997) and the shaded boxes are the areas that woven CAD design is concerned with.

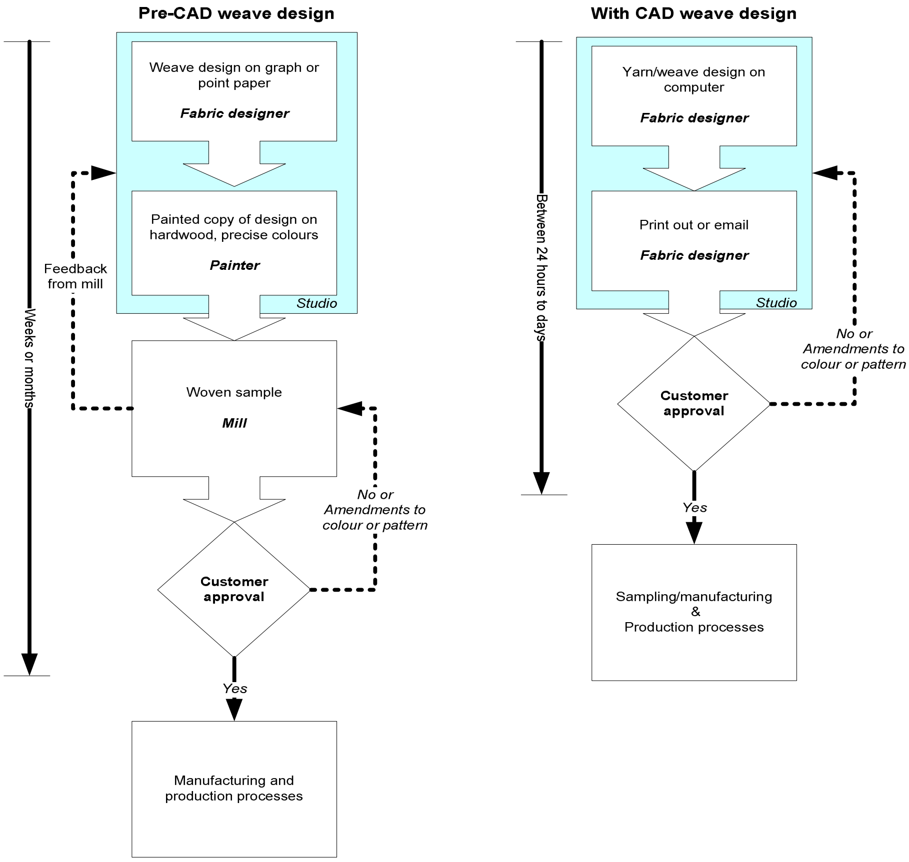
It is well known that the use of CAD reduces time spent on product development. Indeed, in some areas of weaving CAD is essential (eg in jacquard weaving). According to Price et al (1999), CAD came to be used in the large textile manufacturing firms in the USA since the 1980's. The weave design process in the USA would often takes weeks or months to complete as the weave design was first conceived of and drawn onto graph or point paper by the fabric designer and then copied onto board by a painter to the exact and precise colours of the design. This board would be sent to the mill for a sample to be woven for approval by the client. Any amendments would be noted and fed back to the studio by the mill. With the advent of CAD, the designer is able to design or decide which yarns will be employed, draw out the weave design in the computer, either print or email (as JPEG or another file) to the customer and make any amendments as required.

**Figure 3: fabric formation (after EPA 1997)**




Computer screen and printer calibration technology has enabled a 'real-life/virtual' sampling technique, although further approvals may still be required before final production commences. Figure 4 illustrates the changes in timing and the closer relationship between customer/client and designer enabling quicker communications and more creative decision making regarding the final product.

**Figure 4: weave design before and after introduction of CAD technology (after Price et al, 1999)**




CAD therefore, in the first instance, enabled the following: value added merchandise to be designed, shorter production cycles and direct communication between buyer and designer. As CAD systems commonly now have draping and texture mapping functions, it is also possible to visualise the end products (be they interiors, garments etc). It is also possible to request a particular design from the designer as they can scan in a design and reinterpret through the software into a weave design for the client.

The use of CAD is of increasing strategic importance in the supply chain (Wang and Chan 2010). The nature of the textiles supply chain has changed from a linear sequential or serial system to a network system. Globalisation and the effects of globalisation have profoundly changed sourcing and manufacturing as well as trading and the market place. To compete, a company needs to have greater flexibility and quicker response. As supply chains have dispersed geographically they have become increasingly dynamic in nature, requiring ever greater communication and networking. Intra-organisational networking has been common place as communication within a company is vital for it to progress. Information technology has made inter-organisational networking increasingly common as different companies begin to form virtually integrated operations to cope with competitive pressures.

Virtual integration differs from vertical integration as it enables flexibility and responsiveness (Wang and Chan 2010). CAD is a form of IT and this has helped partnering companies in product development to achieve greater and more effective co-operation, communication and higher productivity with lower costs. Therefore, use of the same IT and CAD systems helps companies to understand each other better (eg product specifications are in the same 'language') but raises the following issues that have to be addressed in order for the network to continue to flourish:

- Trust between members within a network regarding technology, intellectual property, time to market of new products,
- Shared resources and competencies,
- Agreement on size of network (for the market size and its constraints),
- Optimisation of the global supply and, in some cases,
- Possible technology 'lock-in' whereby the use of a particular platform is necessary to enter the virtually integrated network.

### 6.8 New products/markets and Future Trends through the use of CAD

While the textiles industry has gradually become ever more mechanised and reliant on the use of CAD/CAM architecture of its production plants, the area of technical textiles has been growing and is now a means of competitive advantage for saturated textiles producing economies. This sector has been described as a growth area, and, indeed, a report in 2006 stated that the technical textiles sector was a dynamic and buoyant one with an annual growth of 5% (Chen, et al, 2006, Miozzo et al 2005); however, because of the problems in defining the sector, measuring the size of the market is a difficult one. Kowalski and Molnar (2009) described some of the efforts to try to estimate the size of this sector which include dividing the market into (i) traditional, (ii) technical and (iii) mixed textile product categories.

(i). Traditional textiles have been described as being: silk, cotton, wool and other vegetable textile fibres.

(ii). Technical textiles have been described as man-made filaments made of ,or containing, nylon, polyamide, polyester, polypropylene, viscose; man-made staple fibres and impregnated, coated or laminated textile fabric (*e.g.* various man-made tyre cord fabrics.

(iii). Mixed textiles products are those manufactured from both traditional and man-made fibres such as: wadding, felt, nonwovens, yarns, twine, cordage, carpets, knitted or crocheted fabric.

Despite these problems of categorisation, Kowalski and Molnar (2009) noted that exports from China and India are increasingly technical textiles. According to Byrne (2000) a major, influential textiles industrial exhibition, Techtextil, was launched in 1985 which provided a taxonomy that has been used to describe the various industry and market sectors that technical textiles are applied in:

- **Agrotech** - agriculture, horticulture, forestry and aquaculture textiles
- **Buildtech** - building and construction textiles
- **Clothtech** - technical components of shoes and clothing e.g. linings
- **Geotech** - geotexiles and civil engineering materials
- **Hometech** - technical components of furniture, household textiles & floorcoverings
- **Indutech** - textiles for industrial applications eg,  filtration, conveying, cleaning etc
- **Medtech** - hygiene and medical products
- **Mobiltech**- automobiles, shipping, railways and aerospace
- **Oekotech** - environmental protection
- **Packtech** - packaging materials
- **Protech** - personal and property protection
- **Sportech**- sport and leisure

Notwithstanding the actual size and share of the textiles market, CAD knowledge and expertise has had a powerful influence on the technical textiles sector. Of increasing interest are composite textiles (textile reinforced composite materials) which have been described as "multiphase materials within which the phase distribution and geometry have been deliberately tailored to optimise one or more properties" (Ogin, 2000, p264) and as "such that they do not dissolve or merge completely into each other" (Wiggers, 2007, p.1). Ogin (2000) continues to describe textile composites such as fiber reinforced plastics (FRP). FRP use fibrous materials - such as carbon fibres, glass fibres, boron, ceramic, aramid or textiles, to mechanically enhance the strength and elasticity of a plastics matrix (which may be polymers - such as epoxide, polyester, nylon-, metals). FRP is used where the following are necessary: weight savings, precision engineering, finite tolerances, and the simplification of parts in both production and operation for low costs and high volume production while maintaining or even improving on performance using more traditional materials such as steel or aluminum. They have been used in the automotive and aerospace industries.  Textiles have been used in industrial composites for over a century (Wiggers, 2007) and therefore it is a mature application, however the use of CAD, advances in computational modelling and mathematical analysis techniques have seen an increasing replacement of other fibres with textiles as opposed to carbon or glass fibres.

Textiles have the advantage of cost, enhanced by processibility and adequate or improved mechanical properties. Woven textile composites have been used very successfully in aerospace because it is light, has good drapeability, allows complex shapes to be formed without gaps and costs are lowered as biaxial fabrics have replaced two layers of nonwoven fabrics. Woven textiles also have the advantage of increased resistance to damage from impact and compression strength but the disadvantage of lower stiffness and strength than nonwoven textiles and so less resistant to deformation (Wiggers, 2007).

Technical textiles require high input of R&D efforts as well as new technology. This subject area has been advanced through the development of  user-friendly software systems for designing woven structures based on mechanical and geometrical modelling with the aim of creating close-to-reality geometrical models for analysing mechanical, fluid, and thermal properties. This type of modelling is essential in systems such as predicting fluid filtration performance through filtration textiles, 3D hollow composites for energy absorption, shock absorption or anti-ballistics performance, etc. (Chen et al 2006, Chen, 2010).

Efforts in textiles woven CAD applications are continuing in the areas of colour, drape and yarn modelling which can have applications in either the commercial or technical areas. Linked up with other digital applications there are possibilities for visualising, characterising, modelling and predicting textiles properties with a view towards manufacture. Traditional jacquard designing, reliant on the skills of craftsmanship of freehand design for copying through the mechanical weave loom, is assisted through the application of CAD systems. Digital jacquard technology incorporates CAD and digital production technology (electronic jacquard machine and new-generation weaving looms). This enables total digital control of design and production, and all data from design to weaving are processed, controlled and transmitted via the computer. Digital jacquard technology has enabled jacquard fabrics with photo-realistic effects with a mega-level colour number on the face of the fabric, raising the potential for security applications of this research (Ng and Zhou 2009). Advances in modelling dry drape of textiles have their applications in the development of predictive modelling for 3D woven technical textiles (composites) as well as garment design and manufacture and reverse engineering of weave structures from samples of fabric, useful in security applications (Xin, et al, 2009).

### 6.9 Sources of further information and advice

The reader is directed to visit the following websites for further information and advice:

www.UCAS.com an organisation that manages applications to higher education courses in the UK, in order to help students make informed choices about their applications, there is a datbase of courses at all universities around the UK. This website will provide the initial information regarding any details about courses at universities to attend regarding textiles and CAD

http://www.skillset.org/fashion_and_textiles/ Skillset, an industry body which supports skills and training for people and businesses in the UK creative industries: they provide news and information about several creative sectors, such as: advertising, animation, computer games, facilities, fashion and textiles, film, interactive media, photo imaging, publishing, radio, tv.

https://ktn.innovateuk.org set up by the government and in collaboration with industry, the Technology Strategy Board have developed a Knowledge Transfer Network which is a tool to help collaborate, disseminate and share knowledge and seek funding for projects. There are a number of groups: environmental sustainability, materials, technical textiles, creative industries, etc.

Further information regarding the software programmes reviewed under the consumer applications is available at the following websites:

www.ScotWeave.com

www.arahne.si

www.textronic.com

www.avacadcam.com

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